ACCOMPLISHMENT REPORT

PROPULSION DIRECTORATE
January 1999

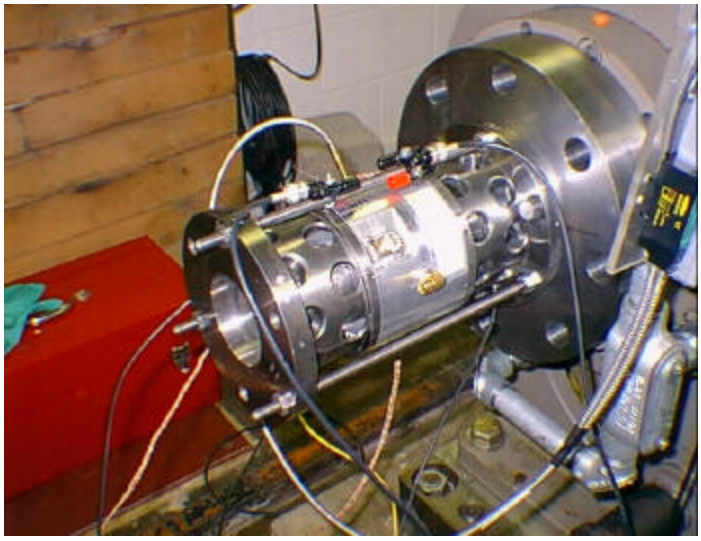
GROUND TESTING OF ELECTRIC ACTUATION SYSTEM BEGINS: Lockheed Martin has begun ground testing an electric flight control actuation system being developed under the Joint Strike Fighter/Integrated Subsystems Technology (J/IST) Program. The purpose of the program is to demonstrate More Electric Aircraft (MEA) technology. MEA technology focuses on replacing centralized hydraulic systems with "power-by-wire" electrical systems that reduce ground support equipment, aircraft weight, and operating cost. The Power Division (AFRL/PRP) is heavily involved in this program and has provided the 270 VDC power management and distribution (PMAD) system and the switch reluctance external integral starter generator (ISG). The electric actuation system will be flight tested on the Advanced Fighter Technology Integration (AFTI) F-16 aircraft. Electric power actuators will drive the flaps, horizontal tail, and rudder of the AFTI F-16, and tests will be performed without a backup hydraulic actuation system. The electric actuation system is targeted for use on the future multi-role fighter. Flight-testing is scheduled to begin by mid-1999 at Lockheed Martin's Fort Worth, Texas, plant and testing will then move to Edwards AFB, California. Results of the J/IST Program will be available to support development of both Boeing and Lockheed JSF concepts. (Maj J. McNamee, AFRL/PRP, (937) 255-6226)

AFTI F-16

VAPOR PHASE LUBRICATED HYBRID ROLLER BEARING READY FOR JETEC DEMO: Thanks to the joint efforts of the Lubrication Branch (AFRL/PRSL) and Allison Engine Company, a vapor phase (VP) lubricated hybrid roller bearing is ready for demonstration in the Joint Expendable Turbine Engine Concept (JETEC) Phase II demonstrator engine. Allison recently demonstrated good bearing performance throughout the entire operating range required for the demonstrator engine. In previous attempts, Allison had limited success at several points of the operating regime but had been unable to demonstrate adequate performance throughout the entire engine test profile. Design changes recommended by PRSL engineers allowed the bearing to achieve steady state operation throughout the entire test profile. Particularly, the inner race geometry was modified to allow increased heat transfer from the contact zone, preventing excessive bearing surface temperatures. As a result, the stationary bearing outer race operated 60°F to 100°F cooler than before and the inner race temperature is projected to be several hundred degrees lower than before. Performance improved significantly due to the reduced

temperatures, and the new configuration is also more rotor-dynamically stable than the prior configuration. Post-test bearing contact surfaces were highly polished indicating good VP lubrication. Assembly of the JETEC demonstrator engine was completed in December and testing is expected to commence in January 1999. (L. Rosado, AFRL/PRSL, (937) 255-6519)

HIGH-SPEED ROTOR AIRFLOW MEASUREMENTS COMMENCE: In-house research by the Power Generation Branch (AFRL/PRPG) for switched-reluctance machines (SRMs) was previously performed to quantify rotor windage power loss and rotor surface heat transfer efficiency. This research was performed to improve the prediction of SRM operating conditions when ambient air is the coolant as is planned for SRMs used in the Integrated Power Unit (IPU) Thermal/Energy Management Module (T/EMM) and other flight-capable turbogenerators. Understanding of rotor heat transfer is essential to ensure that high power-dense machine rotors do not approach internal temperatures that degrade performance and reduce component life. Future in-house research is planned to develop air-cooling concepts, but additional knowledge is needed first on the airflow behavior at the SRM rotor ends. In response to this need, an in-house experiment was initiated by PRPG to measure local air velocities close to the rotor ends. A rotating test machine used earlier for windage torque measurement was modified to obtain this data, and the drive stand for this test recently achieved operable status. The drive stand is capable of driving machines to a maximum speed of 100,000 rpm though present airflow tests are constrained to a 30,000 rpm maximum speed pending further development of test cell noise control and overspeed protection. Initial tests have successfully demonstrated the ability to monitor air velocity variance in relation to rotor position. (E. Durkin, AFRL/PRPG, (937) 255-6241)



Test Rig for High Speed Rotor Airflow Measurements

U-2 Reconnaissance Plane

ADDITIVE TO REDUCE JP-8 FREEZE POINT: The Fuels Branch (AFRL/PRSF) has initiated a program to reduce the freeze point of JP-8 through the use of additives. Motivation for this effort stems primarily from a desire to replace JPTS (TS for *thermally stable*), the fuel used for the high-altitude U-2 reconnaissance plane, with the more economical JP-8. The cost of JP-8 is approximately one-third the cost of JPTS ($0.80/gallon vs $2.50/gallon). JP-8 can currently meet JPTS thermal stability

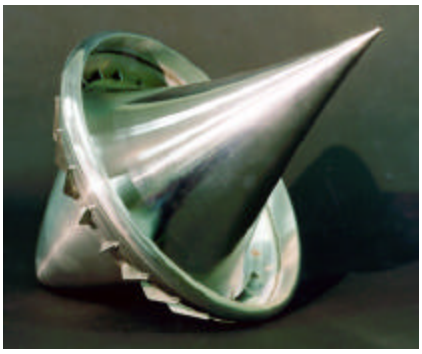
requirements through the use of the +100 additive package, but it falls short of the JPTS low temperature capabilities. Working with the University of Dayton Research Institute (UDRI), PRSF will evaluate additives in a fashion similar to the highly successful JP-8+100 program, which developed an additive package to improve JP-8 thermal stability. The goal is to develop an additive that will allow the fuel to flow readily below its nominal freeze point, thus extending its useful operational temperature range. The Canadian Ministry of Defense, whose aircraft often encounter extreme low temperature conditions, has expressed further interest in the development of such an additive. There is also interest from the commercial sector, where an increase in transpolar and Siberian flights from Asia has highlighted a need for cost-effective, low temperature fuels. Progress on development of the additive will be presented at the International Symposium of Air Breathing Engines (ISABE) conference in Florence, Italy, later this year. (C. Obringer, AFRL/PRSF, (937) 255-6390)

THREAT PROGRAM REACHES MILESTONE: The Hybrid Rocket Engine Applied Technology (THREAT) Program reached a major milestone in December 1998 when subcontractor Rocketdyne had its critical design review (CDR) of a flight-like injector. This joint program between the US Air Force and the Japanese Defense Agency exists to develop hybrid rocket propulsion technology aimed at the tactical theater. The CDR covered all aspects of the design. A major design requirement is for the injector to handle a 2:1 throttle ratio between the boost and sustain flow conditions. Issues associated with this arrangement were presented and discussed. Parameters such as pressures and forces required for actuation, flow velocities through the various channels, and the temperature range compatibility of the moving parts in a high viscosity fluid environment were covered. This full-scale test injector will be tested with various oxidizer simulants to ascertain the effects of variations of viscosity and temperature on the operation of the injector assembly. (L. Quinn, AFRL/PRR, (805) 275-5630)

SUCCESSFUL SUBSTRATE DEVELOPED FOR YBCO: Plastronic Inc, a subsidiary of EURUS Technologies Inc, through a Ballistic Missile Defense Organization (BMDO) STTR Phase I, has reported several successful results in developing textured metal substrates for yttrium barium copper oxide (YBCO) coated superconductors. Development of these substrates supports high-power lightweight generators required as a power source for directed energy weapons. Plastronic's proprietary post-processing of textured nickel dramatically reduced undesirable residual background texture and twinning. The in-house PRP superconductivity group (joint with Materials Directorate) helped to subsequently deposit buffer layers and YBCO on the nickel substrates to demonstrate successful deposition on the substrates. A metal texture was further demonstrated to be maintained in a tape configuration that can lead to a multi-filament type conductor, versus the current monofilament tapes that are currently being demonstrated. A multi-filament configuration will be of great benefit for Air Force's aircraft applications. Through Plastronic's STTR partner, Oak Ridge National Laboratory, nonmagnetic substrates of textured Ni-Cr alloys have been developed and coated with YBCO resulting in current densities of over 230,000 amps/cm^2 at 77K. (P. Barnes, AFRL/PRPS, (937) 255-2923)

LIGHTCRAFT TEAM REACHES SEMI-FINALS: The Laser Lightcraft team was recently notified that they are semi-finalists in the 10th Annual Discover Magazine Awards for Technological Innovation competition. The Lightcraft project is striving to develop a unique vehicle that can be propelled into space on a beam of light provided by a ground-based laser.

Currently, AFRL/PR and NASA Marshall Space Flight Center are supporting Lightcraft research being performed by Rensselaer Polytechnic Institute. The Lightcraft team was invited to submit documentation to support their nomination, and the team responded by sending an impressive collection of technical reports, pictures, news releases, and magazine articles. The ultimate winner, to be announced later this year, will receive a $100,000 prize presented by the Christopher Columbus Fellowship Foundation. (F. Mead, AFRL/PRSP, (805) 275-5929)



The Laser-Propelled Lightcraft

NEW SOLAR POWER EXPERIMENT CONCEIVED: In 1998, the Ballistic Missile Defense Organization (BMDO) supported the Deep Space 1 space flight to demonstrate a solar photovoltaic concentrator array. As a result of this flight test, a follow-on test is being proposed to demonstrate the array's radiation hardness. Included in this experiment is a planned test for plasma breakdown linked to a high-voltage array's failure. BMDO approached the Power Division (AFRL/PRP) to manage a plasma breakdown experiment that would be conducted jointly with the Space Vehicles Directorate (AFRL/VS) and Able Engineering. PRP personnel brainstormed a conceptual solution to the cause of the plasma breakdown. The suggested reason is that solar irradiants generate a static charge on the array's glass surface which arcs to the photovoltaic cell and produces sufficient plasma to "short out" the cell string to ground. To test this supposition, two cell strings will be used with one string covered by a special glass that bleeds off the static charge, and the performance of these strings will be compared to an in-house model. BMDO is interested in these results because of the potential need of high-power photovoltaic power systems for future satellites and other space platforms. (J. Beam, AFRL/PRP, (937) 255-6226)

Solar Concentrator Array

NHTF'S CHENAULT IMPRESSES NASA: Recognition for a job well done goes to Stephanie Chenault of the National Hover Test Facility (NHTF) at Edwards AFB. NHTF personnel will be performing the propellant loading operations at Kennedy Space Center (KSC) for the Space Vehicles Directorate's (AFRL/VS) XSS-10 flight experiment. The XSS-10, the first of a series of space inspection flight experiments, is scheduled to fly as a payload on the Space Shuttle in the fall of 1999. In November 1998, during the height of preparations for exoatmospheric kill vehicle (EKV) testing, Stephanie Chenault digested KSC's 300-page Safety Data Package. She evaluated the status of current NHTF propellant loading equipment and the modifications required to meet KSC standards. She then prepared and delivered an excellent presentation to a NASA representative who left with an excellent attitude towards NHTF and their ability to perform these operations at their facility in a safe and professional manner. (L. Quinn, AFRL/PRR, (805) 275-5630)

COOPERATIVE AGREEMENTS SUPPORT HTS RESEARCH: Cooperative agreements with Intermagnetics General Corp (IGC) and the University of Wisconsin-Madison were started at the end of 1998 to support coated conductor research for lightweight, high-temperature superconducting (HTS) motors and generators. The agreement with IGC supports post-oxygenation studies conducted by the AFRL/PRPS superconductivity group. Recent research has indicated improvement in the properties of deposited HTS yttrium barium copper oxide (YBCO) films. YBCO is of interest because it allows large current densities at liquid nitrogen temperatures (-320°F), which is a significant improvement over present superconductors that operate at or near liquid helium temperatures (-452°F). IGC is to conduct studies on YBCO films generated at a different location and by a different process. Film deposition by PRPS is done with Pulsed Laser Deposition (PLD), while IGC employs Metal-Organic Chemical Vapor Deposition (MOCVD). Although PLD currently provides the best YBCO films, the MOCVD process may provide quality films at a higher deposition rate. The agreement reached with the University of Wisconsin-Madison is to provide transmission electron microscopy (TEM) and magneto optical imaging (MOI) diagnostic services. The PRPS superconductivity group does not perform either of these diagnostic methods. These cooperative efforts will aid PRPS in their efforts to advance HTS technology. (P. Barnes, AFRL/PRPS, (937) 255-2923)

Dr. Leslie Perkins

ROCKET SCIENTIST CARES FOR COMMUNITY: Dr. Leslie Perkins has shown unparalleled dedication to the community and environment surrounding Edwards AFB, California. A computational chemist for the Propulsion Directorate, Dr. Perkins also serves as the AFRL Propulsion Directorate (AFRL/PR) representative to the Edwards AFB Restoration Advisory Board (RAB). The RAB is an organization committed to informing and educating the public about continuing efforts to clean up contamination at Edwards AFB. Dr. Perkins takes her position on the RAB very seriously and exercises her duties with an admirable commitment to the safety and well being of the local community. She strives to show the public the human face of the Air Force, and she shares the public's concern about the issues under consideration by the RAB. A more detailed article on Dr. Perkins can be found in the November 1998 issue of the Edwards AFB *Report to Stakeholders* (see web address below). (J. Pearce, AFRL/PRO, (937) 255-5451)
[see http://afftc.edwards.af.mil:80/penvmng/cleanup/RTS/1998rts/Nov98/novrts98pg5.htm]